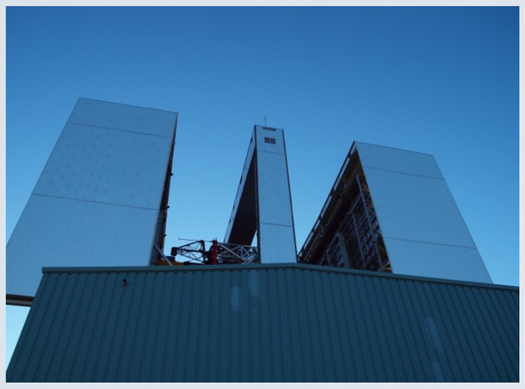

The Environment of the Luminous Quasar PDS456

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The low-redshift, bright quasar, PDS456 (z=0.184, V~14) is one of the most powerful and intriguing quasars in the local Universe. PDS 456 is both an ultraluminous infrared galaxy (ULIRG) and a QSO, making it one of the nearest transition objects. X-ray observations reveal powerful, ultrafast outflows (e.g. Nardini et al. 2015), and far infrared and radio observations place it at the upper extreme in star formation efficiency (Yun et al. 2004, Y04). Ground-based near-IR imaging (Y04) shows three K-band sources (hereafter K1 and the merged K2+K3) less than 3" away, at projected distances less than ~9 kpc from the nucleus.

Here, we present rest-frame optical spectra from MODS which confirm the relation of one of these sources to the quasar and reveal a narrow emission line region, also at the quasar redshift, at the same position angle as K1 but at a projected distance of ~20 kpc. The spectra of K1, and also K2+K3, are consistent with those of old stellar populations. Narrow-band imaging observations at redshifted Hα were made in an attempt to pinpoint the location of the narrow emission line region and look for others. Analysis of these and of near-IR LUCI spectroscopic and imaging data is in progress and here we present an LBC image at i', which for z=0.184 contains Hα.

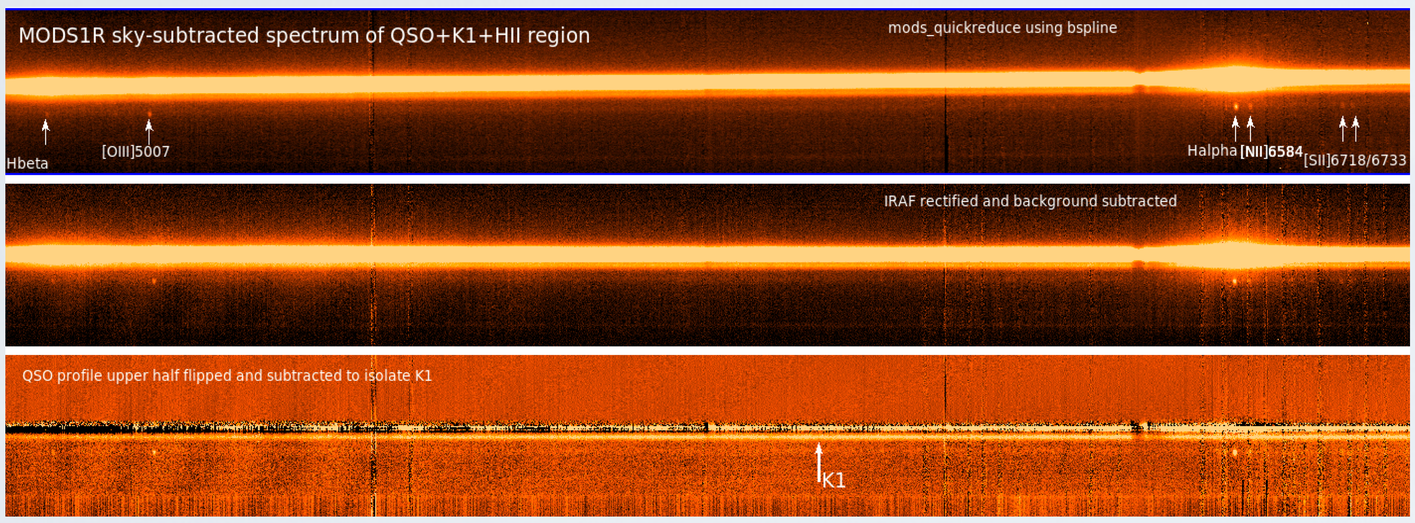


Figure 1: A one hour MODS red channel spectrum of K1 with a serendipitous discovery of a narrow emission line region 6.55" (~20 kpc) from the nucleus. [OII]3727 is detected in the blue spectrum and Hβ, [OIII]4959,5007, [NII]6548,6584, Hα and [SII] 6718,6733 in the red as shown above. The narrow lines are unresolved – Hα has a FWHM ~ 4.8 Angstroms and a flux ~ 1.8e-16 erg/s/cm^2 which at z=0.184 implies an Hα luminosity, L(Hα) ~ 1.e40 erg/s. The three panels highlight two challenges of the data reduction: sky subtraction and spectral decomposition. The data were initially reduced in IRAF (middle panel), but the *bspline* algorithm used by the XIDL-based MODS pipeline (top panel) does a better job removing the sky lines, as can be seen especially for the many OH Meinel bands in the red. The bottom panel shows the result of subtracting the symmetry-flipped profile to isolate K1, only 2.5" away from the 5-magnitudes brighter quasar. More work is needed to achieve a cleaner subtraction of the quasar's profile, although already the background can be seen on either side of K1.

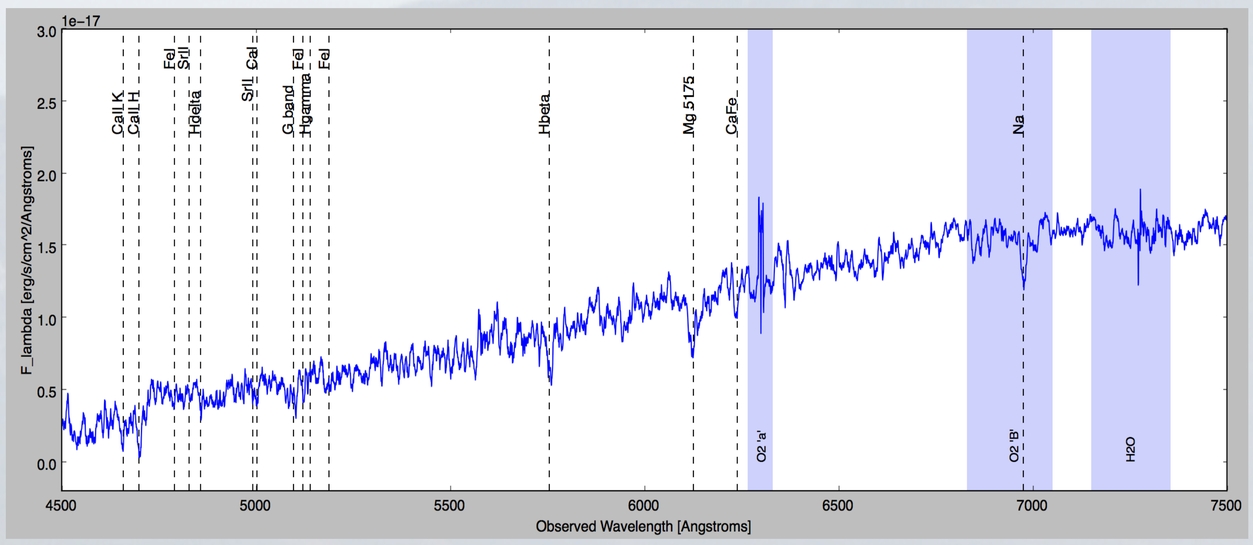


Figure 2: MODS1 spectrum of the source, K1, smoothed to the resolution of the 1" slit. The source is over 5 magnitudes fainter than the quasar and ~2.5" away. Its spectrum was extracted after the quasar profile was symmetry-flipped and subtracted. It has absorption lines characteristic of an old stellar population and is at a redshift consistent with that of the quasar, z=0.184. Cross-correlation with stellar spectral templates will allow more precise line-of-sight velocity, as well as velocity dispersion estimates, enabling a study of the kinematics and dynamics of these companions. Reduction of a shallower, 15-min total, spectrum of K2+K3 indicates that it is also at the quasar redshift.

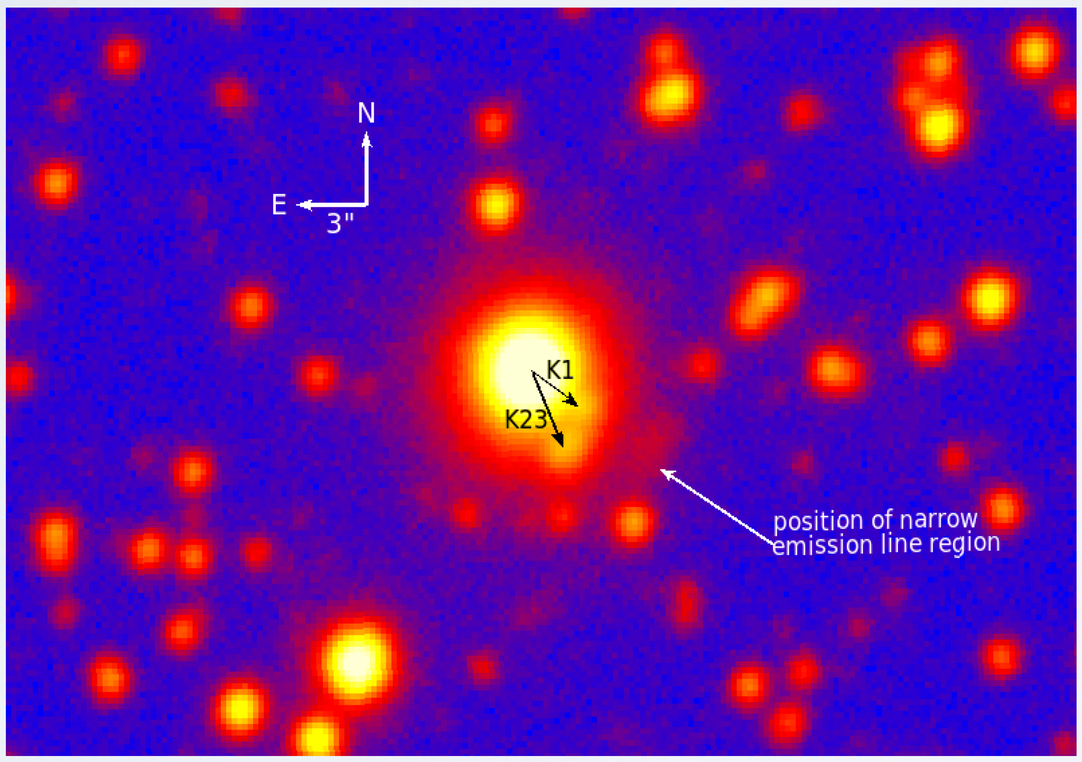
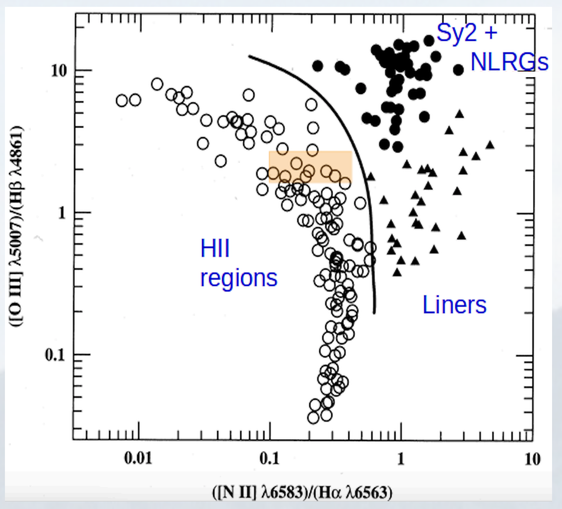


Figure 3: The arrows overplotted on this 315-sec LBCR image at i' (above) point to the K-band sources of Y04 that lie 2.5" to the WSW (K1) and 3.2" to the SW (K2+K3) of the nucleus and to the expected location of the narrow emission line region that lies along the same position angle as K1 but over twice as far from the nucleus, at 6.55" (~20 kpc). *ds9*'s minmax log stretch was used to show both the K-band sources close to the quasar and a region of diffuse emission that appears to lie just within the emission line region. The next step is to try image deconvolution to look for a host galaxy. Letawe et al (2010) find evidence for a host galaxy with an undefined (neither spiral or elliptical) morphology, characteristic of an interacting system, from a 60-sec SUSI-NTT V band image after deconvolution.

Figure 4: The narrow emission line source has line ratios characteristic of photoionization by stars, not by the harder nuclear spectrum, as indicated by the location of this source on a BPT diagram from Peterson (1997). The shaded region spans the 1-sigma errors, which represent the uncertainties in measuring the continuum level. This source could be a region of star formation triggered by a merger; it appears to lie along the edge of the diffuse emission which could come from a merger remnant.



Summary: The MODS and LBC data suggest that the quasar PDS456 is not an isolated system, but has undergone and may still be undergoing interactions with its neighbors. This is consistent with its nature as a ULIRG-to-QSO transition object. As the kinematics and narrow band imaging are analyzed further, we aim to extract dynamical information about the system, constrain the star-formation rates and the ages of the stellar populations, and consider how these may relate, if at all, to powerful outflows in the nuclear region.

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